CLAIMS

1. A power output apparatus that outputs power to a drive shaft, said power output apparatus comprising:

an internal combustion engine;

an electric power-mechanical power input-output unit that is linked with an output shaft of said internal combustion engine and with the drive shaft to maintain or vary a driving state of said internal combustion engine and to output at least part of power from said internal combustion engine to the drive shaft through inputs and outputs of electric power and mechanical power;

a motor that is capable of inputting and outputting power from and to the drive shaft;

a secondary battery that is capable of supplying and receiving electric power to and from said electric power-mechanical power input-output unit and said motor;

an input restriction setting module that sets an input restriction of said secondary battery;

a charge-discharge electric power measurement module that measures a charge-discharge electric power used to charge said secondary battery or obtained by discharging said secondary battery;

a power demand setting module that sets a power demand required to the drive shaft, in response to an operator's manipulation;

a driving state varying mode changeover module that, in response to setting of an abruptly decreasing power demand by said power demand setting module, selects a driving state varying mode to vary the driving state of said internal combustion engine, based on the charge-discharge electric power measured by said charge-discharge electric power measurement module and the input restriction set by said input restriction setting module; and

a controller that controls said internal combustion engine, said electric power-mechanical power input-output unit, and said motor to ensure a variation in driving state of said internal combustion engine in the selected driving state varying mode and output of a power corresponding to the setting of the power demand to the drive shaft.

2. A power output apparatus in accordance with claim 1, wherein said driving state varying mode changeover module selects an ordinary state varying mode to gradually vary the driving state of said internal combustion engine when the measured charge-discharge electric power is less than a predetermined first electric power set on the basis of the input restriction, said driving state varying mode changeover module selecting an independent state varying mode to idle said internal combustion engine at a specified revolution speed without torque output and thereby vary the driving state of said internal combustion engine when the measured charge-discharge electric power is not less than the

predetermined first electric power but is less than a predetermined second electric power set on the basis of the input restriction, said driving state varying mode changeover module selecting a fuel supply shutoff state varying mode to shut off fuel supply to said internal combustion engine and thereby vary the driving state of said internal combustion engine when the measured charge-discharge electric power is not less than the predetermined second electric power.

3. A power output apparatus in accordance with claim 2, wherein the predetermined second electric power is set to be a lower level than the input restriction.

4. A power output apparatus in accordance with claim 2, wherein the predetermined second electric power is set to be a higher level than the input restriction.

5. A power output apparatus in accordance with claim 2, wherein the predetermined first electric power is set to be a lower level than the input restriction.

6. A power output apparatus in accordance with claim 1, wherein said driving state varying mode changeover module selects the driving state varying mode of said internal combustion engine, based on a degree of a variation in measured charge-discharge electric power that has reached a predetermined first electric power set on the basis of the input restriction.

7. A power output apparatus in accordance with claim 6, wherein said driving state varying mode changeover module

selects an ordinary state varying mode to gradually vary the driving state of said internal combustion engine when the degree of the variation in measured charge-discharge electric power is less than a predetermined first level, said driving state varying mode changeover module selecting an independent state varying mode to idle said internal combustion engine at a specified revolution speed without torque output and thereby vary the driving state of said internal combustion engine when the degree of the variation in measured charge-discharge electric power is not less than the predetermined first level but is less than a predetermined second level, said driving state varying mode changeover module selecting a fuel supply shutoff state varying mode to shut off fuel supply to said internal combustion engine and thereby vary the driving state of said internal combustion engine when the degree of the variation in measured charge-discharge electric power is not less than the predetermined second level.

8. A power output apparatus in accordance with claim 7, wherein said driving state varying mode changeover module adopts the fuel supply shutoff state varying mode, regardless of the selected driving state varying mode when the measured charge-discharge electric power has reached the predetermined first electric power, on the condition that the measured charge-discharge electric power is not less than a predetermined second electric power, which is set on the basis of the input restriction to be greater than the predetermined

first electric power.

9. A power output apparatus in accordance with claim 8, wherein the predetermined second electric power is set to be a lower level than the input restriction.

10. A power output apparatus in accordance with claim 8, wherein the predetermined second electric power is set to be a higher level than the input restriction.

11. A power output apparatus in accordance with claim 6, wherein the predetermined first electric power is set to be a lower level than the input restriction.

12. A power output apparatus in accordance with any one of claims 1 through 11, wherein said electric power-mechanical power input-output unit comprises:

a three-shaft power input-output assembly that is connected with three shafts, that is, said output shaft of said internal combustion engine, said drive shaft, and a third shaft, and specifies input and output of power from and to one residual shaft among said three shafts, based on powers input and output from and to two shafts among said three shafts; and

a generator that inputs and outputs power from and to said third shaft.

13. A power output apparatus in accordance with any one of claims 1 through 11, wherein said electric power-mechanical power input-output unit comprises a pair-rotor generator having a first rotor, which is linked with the output shaft of said internal combustion engine, and a second rotor, which

is linked with said drive shaft and rotates relative to the first rotor, said pair-rotor generator outputting at least part of the power from said internal combustion engine to said drive shaft through input and output of electric power by electromagnetic interaction between the first rotor and the second rotor.

14. An automobile, comprising:

an internal combustion engine;

an electric power-mechanical power input-output unit that is linked with an output shaft of said internal combustion engine and with a drive shaft connecting to an axle to maintain or vary a driving state of said internal combustion engine and to output at least part of power from said internal combustion engine to the drive shaft through inputs and outputs of electric power and mechanical power;

a motor that is capable of inputting and outputting power from and to the drive shaft;

a secondary battery that is capable of supplying and receiving electric power to and from said electric power-mechanical power input-output unit and said motor;

an input restriction setting module that sets an input restriction of said secondary battery;

a charge-discharge electric power measurement module that measures a charge-discharge electric power used to charge said secondary battery or obtained by discharging said secondary battery;

a power demand setting module that sets a power demand required to the drive shaft, in response to an operator's manipulation;

a driving state varying mode changeover module that, in response to setting of an abruptly decreasing power demand by said power demand setting module, selects a driving state varying mode to vary the driving state of said internal combustion engine, based on the charge-discharge electric power measured by said charge-discharge electric power measurement module and the input restriction set by said input restriction setting module; and

a controller that controls said internal combustion engine, said electric power-mechanical power input-output unit, and said motor to ensure a variation in driving state of said internal combustion engine in the selected driving state varying mode and output of a power corresponding to the setting of the power demand to the drive shaft.

15. An automobile in accordance with claim 14, wherein said driving state varying mode changeover module selects an ordinary state varying mode to gradually vary the driving state of said internal combustion engine when the measured charge-discharge electric power is less than a predetermined first electric power set on the basis of the input restriction, said driving state varying mode changeover module selecting an independent state varying mode to idle said internal combustion engine at a specified revolution speed without

torque output and thereby vary the driving state of said internal combustion engine when the measured charge-discharge electric power is not less than the predetermined first electric power but is less than a predetermined second electric power set on the basis of the input restriction, said driving state varying mode changeover module selecting a fuel supply shutoff state varying mode to shut off fuel supply to said internal combustion engine and thereby vary the driving state of said internal combustion engine when the measured charge-discharge electric power is not less than the predetermined second electric power.

16. An automobile in accordance with claim 14, wherein said driving state varying mode changeover module selects the driving state varying mode of said internal combustion engine, based on a degree of a variation in measured charge-discharge electric power that has reached a predetermined first electric power set on the basis of the input restriction.

17. An automobile in accordance with claim 16, wherein said driving state varying mode changeover module selects an ordinary state varying mode to gradually vary the driving state of said internal combustion engine when the degree of the variation in measured charge-discharge electric power is less than a predetermined first level, said driving state varying mode changeover module selecting an independent state varying mode to idle said internal combustion engine at a specified revolution speed without torque output and thereby vary the

driving state of said internal combustion engine when the degree of the variation in measured charge-discharge electric power is not less than the predetermined first level but is less than a predetermined second level, said driving state varying mode changeover module selecting a fuel supply shutoff state varying mode to shut off fuel supply to said internal combustion engine and thereby vary the driving state of said internal combustion engine when the degree of the variation in measured charge-discharge electric power is not less than the predetermined second level.

18. An automobile in accordance with claim 17, wherein said driving state varying mode changeover module adopts the fuel supply shutoff state varying mode, regardless of the selected driving state varying mode when the measured charge-discharge electric power has reached the predetermined first electric power, on the condition that the measured charge-discharge electric power is not less than a predetermined second electric power, which is set on the basis of the input restriction to be greater than the predetermined first electric power.

19. An automobile in accordance with either one of claims 14 and 18, wherein said electric power-mechanical power input-output unit comprises:

a three-shaft power input-output assembly that is connected with three shafts, that is, said output shaft of said internal combustion engine, said drive shaft, and a third shaft,

and specifies input and output of power from and to one residual shaft among said three shafts, based on powers input and output from and to two shafts among said three shafts; and

a generator that inputs and outputs power from and to said third shaft.

20. An automobile in accordance with either one of claims 14 and 18, wherein said electric power-mechanical power input-output unit comprises a pair-rotor generator having a first rotor, which is linked with the output shaft of said internal combustion engine, and a second rotor, which is linked with said drive shaft and rotates relative to the first rotor, said pair-rotor generator outputting at least part of the power from said internal combustion engine to said drive shaft through input and output of electric power by electromagnetic interaction between the first rotor and the second rotor.

21. A control method of a power output apparatus that comprises: an internal combustion engine; an electric power-mechanical power input-output unit that is linked with an output shaft of said internal combustion engine and with a drive shaft to maintain or vary a driving state of said internal combustion engine and to output at least part of power from said internal combustion engine to the drive shaft through inputs and outputs of electric power and mechanical power; a motor that is capable of inputting and outputting power from and to the drive shaft; and a secondary battery that is capable of supplying and receiving electric power to and from said

electric power-mechanical power input-output unit and said motor,

said control method comprising the steps of:

(a) setting an input restriction of said secondary battery;

(b) measuring a charge-discharge electric power used to charge said secondary battery or obtained by discharging said secondary battery;

(c) setting a power demand required to the drive shaft, in response to an operator's manipulation;

(d) in response to setting of an abruptly decreasing power demand by said step (c), selecting a driving state varying mode to vary the driving state of said internal combustion engine, based on the measured charge-discharge electric power and the setting of the input restriction; and

(e) controlling said internal combustion engine, said electric power-mechanical power input-output unit, and said motor to ensure a variation in driving state of said internal combustion engine in the selected driving state varying mode and output of a power corresponding to the setting of the power demand to the drive shaft.

22. A control method in accordance with claim 21, wherein said step (d) selects an ordinary state varying mode to gradually vary the driving state of said internal combustion engine when the measured charge-discharge electric power is less than a predetermined first electric power set on the basis

of the input restriction, said step (d) selecting an independent state varying mode to idle said internal combustion engine at a specified revolution speed without torque output and thereby vary the driving state of said internal combustion engine when the measured charge-discharge electric power is not less than the predetermined first electric power but is less than a predetermined second electric power set on the basis of the input restriction, said step (d) selecting a fuel supply shutoff state varying mode to shut off fuel supply to said internal combustion engine and thereby vary the driving state of said internal combustion engine when the measured charge-discharge electric power is not less than the predetermined second electric power.

23. A control method in accordance with claim 21, wherein said step (d) selects an ordinary state varying mode to gradually vary the driving state of said internal combustion engine when a degree of a variation in measured charge-discharge electric power, which has reached a predetermined first electric power set on the basis of the input restriction, is less than a predetermined first level, said step (d) selecting an independent state varying mode to idle said internal combustion engine at a specified revolution speed without torque output and thereby vary the driving state of said internal combustion engine when the degree of the variation in measured charge-discharge electric power is not less than the predetermined first level but is less than a

predetermined second level, said step (d) selecting a fuel supply shutoff state varying mode to shut off fuel supply to said internal combustion engine and thereby vary the driving state of said internal combustion engine when the degree of the variation in measured charge-discharge electric power is not less than the predetermined second level.